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ARI Research Note 90-113

AD-A226 949

The Evaluation of Long Range Consequences in Decision Making

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for

Contracting Officer's Representative
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Basic Research
Michael Kaplan, Director

August 1990

United States Army
Research Institute for the Behavioral and Social Sciences

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency Under the Jurisdiction of the Deputy Chief of Staff for Personnel

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Research accomplished under contract for
the Department of the Army

Perdue University

Technical review by

Michael Drillings

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS —
2a. SECURITY CLASSIFICATION AUTHORITY —	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE —	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) —	5. MONITORING ORGANIZATION REPORT NUMBER(S) ARI Research Note 90–113
6a. NAME OF PERFORMING ORGANIZATION Department of Psychology Perdue University 6b. OFFICE SYMBOL (If applicable) —	7a. NAME OF MONITORING ORGANIZATION U.S. Army Research Institute for the Behavioral and Social Sciences
6c. ADDRESS (City, State, and ZIP Code) West Lafayette, IN 47907	7b. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333-5600
8a. NAME OF FUNDING / SPONSORING ORGANIZATION U.S. Army Research Institute 8b. OFFICE SYMBOL (If applicable) PERI-BR	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA903–85-K-0366
8c. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333–5600	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO.: 61102B PROJECT NO.: 74F TASK NO.: NA WORK UNIT ACCESSION NO.: NA

11. TITLE (Include Security Classification)

The Evaluation of Long Range Consequences in Decision Making

12. PERSONAL AUTHOR(S)
Mary Kay Stevenson-Busemeyer

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 85/08 TO 87/08	1990, August	11

16. SUPPLEMENTARY NOTATION
Michael Drillings, contracting officer's representative.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Temporal discounting, Response functioning, Basis splines, Discounting operation, Subjective scale values

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The purpose of this research program is to develop a general model of how individuals make decisions that involve temporally remote or long range consequences. The primary focus of this project is to define the form of the subjective time scales as they vary across situations and individuals, to define the type of discounting operation that is used to qualify incentives when they occur in the future, and to test the way that these processes can be analyzed using different tasks or response measures. A mesurement model has been used as a framework for investigating the way subjects respond to long-term positive and negative consequences. All five of the experiments described in the proposal were completed. This summary report will provide an overview of the progress made toward the objectives defined for this phase of the research program.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL Michael Drillings	22b. TELEPHONE (Include Area Code) (202) 274–8722 22c. OFFICE SYMBOL PERI-BR

DD FORM 1473, JUN 86 *Previous editions are obsolete.*

THE EVALUATION OF LONG RANGE CONSEQUENCES IN DECISION MAKING

MDA 903 85 K 0366 20 AUG 85 - 19 AUG 87

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SCIENTIFIC OBJECTIVES: The purpose of this research program is to develop a general model of how individuals make decisions that involve temporally remote or long range consequences. The primary focus of this project is to define the form of the subjective time scales as they vary across situations and individuals, to define the type of discounting operation that is used to qualify incentives when they occur in the future, and to test the way that these processes can be analyzed using different tasks or response measures.

APPROACH: A measurement model has been used as a framework for investigating the way subjects respond to long term positive and negative consequences. Each subject is assumed to use subjective values in assessing the value of these outcomes across time. The temporal discounting process is tested from a number of different psychological perspectives. The pattern of ratings obtained is also expected to vary according to the task or manner in which the responses are elicited. This effect has been termed the response function or elicitation effect. Therefore for the general model, scale values are derived for each attribute, specific discounting functions are tested, and the response characteristics associated with the various rating tasks are defined.

PROGRESS: All five of the experiments described in the proposal were completed. This summary report will provide an overview of the progress made toward the objectives defined for this phase of the research program. Detailed descriptions of the results are described in one reprint and four technical reports. The results reported in the technical reports will be revised and edited for publication.

In general, progress was made toward developing a model for temporal discounting. The model involves 3 components:

$$S_p = H_p(\Phi_p) \qquad (1a)$$

$$S_v = H_v(\Phi_v)$$

$$S_t = H_t(\Phi_t)$$

$$\Psi_{pvt} = S_p S_v / S_t \qquad (2)$$

$$R_{pvt} = J(\Psi_{pvt}) + e_{pvt} \qquad (3)$$

Scale Values For Time. The first component describes the way individuals perceive the physical values of the stimuli. For example, a millionaire will not place the same subjective value on $100 as will a student who is trying to work his way through college. The subjective scales also reflect the fact that the subjective difference between $5 and $10 is not equivalent to the subjective difference between $1000 and $1005. The probability values and the temporal values are also assumed to have subjective interpretations.

In the current set of studies, the samples have been quite homogeneous, (college students in their first or second year) so individual differences were not detected in most of the studies. However, participants in one study were

selected to assess the possibility of detecting individual differences (engineering, education and business majors). The primary question was whether these anticipated individual differences would only affect the subjective scale values (i.e., first component of the model) or the response scale (i.e., the third component of the model). These results are discussed in the Technical Report on "Preference for Job Attributes: Present and Future".

At the beginning of this series of studies, it was assumed that the scale values for probability, value, and time would be independent of each other. It was discovered that the scale values for both the values of the outcomes and the time that the events occur are influenced by the presence or absence of a risk or explicit probability. These results are discussed in detail in Stevenson (1986). In one case, investments were used as stimuli. When the interest rate was fixed and certain to be obtained, the subjective values were consistently less than were the subjective values obtained when the interest rate was defined in the context of risk. The subjective values for time were different. When the investment period was defined in the context of risk, the subjective times were judged to be consistently shorter than were the subjective times defined under certainty. The lack of scale convergence was also obtained with negative outcomes. In this case, loans which defined the payment periods were compared to risky investments that defined the amount of money that could be lost with a random probability. When payments are certain, the subjective value of the loss is viewed as greater than a loss that is uncertain. The time before that payment must be made is viewed as subjectively shorter than the time preceding an uncertain loss in the future. From these results, it must be concluded that the scaling functions for the attributes of these stimuli are not independent.

In the next study, subjective scale values were obtained for probability, time and both positive and negative outcomes using a different scenario. These results are discussed in detail in the Technical Report, "The Effects of Temporally Based Work and Payment conditions on Funding a College Education". In this case funding programs for college were generated that varied in length of time you could attend school or in length of time you had to work to gain the support. In one task, subjects rated their preference strength for one of two funding programs that varied in the length of time you worked and the level of support that could be obtained. In a second task, subjects were asked to rate the attractiveness of each funding program. For this set of stimuli a risk factor was added. More specifically, the subjects were told that if they flunked out of school, the support would be lost. Therefore, with this set of stimuli the subjective values of the stimulus attributes could be estimated in the context of certainty and uncertainty.

Unlike the previous results, the scale values were quite similar in this experiment. However, in this case, the probabilistic component was not a random event but was determined by the behavior of the participant. Therefore, it was concluded that the effect of probability on the scale values for the outcomes and the time factor depends on the random chance feature of the probabilities. The other set of stimuli that was used with the same subjects described deferred payment plans. A probabilistic tuition lottery was compared to a certain payment schedule. In this situation, the scale values did not converge and showed a similar pattern to those obtained for payments and time with loans. It was concluded that in order to understand the first component of the model, the subjective scaling factors, a study that systematically varies risk will have to be completed to describe the function relating probability to the scaling

functions. This study was proposed for another grant and is currently in progress.

The characteristics of subjective scales for individual subjects were assessed. In general, the results obtained for individual subjects appear to correspond quite closely with the results obtained by averaging over individuals who have very similar patterns of responses. The results are discussed in detail in the Technical Report, "The Effect of Temporally Based Work and Payment Conditions on Funding a College Education."

Finally, the effects of context were assessed by varying the time frame of the investment sets that subjects were asked to evaluate. The mean ratings obtained for the same investment were compared when they were evaluated in the context of other investments that were short range and when they were placed in a context that included more long term investments. The mean ratings changed quite consistently as functions of the investment context. The details of this effect on the subjective scale values are described in the Technical Report, "The Effect of Time Frame on the Evaluation of Future Events."

In summary, the empirical results indicate that subjective scales are influenced by the probabilistic characteristics of events and the time frame which is provided. The current model will be modified to include these factors so that it may be used to describe temporal discounting across these situations. Therefore, the first component should be defined as:

$$S_p = H_c(\Phi_p) \qquad (1b)$$

$$S_v = H_c(\Phi_v, \Phi_p)$$

$$S_t = H_c(\Phi_t, \Phi_p)$$

The subscript, c represents the time frame or context in which the stimuli are presented. The degree of risk, Φ_p has been included as a factor in determining the subjective values for the physical value and time.

Temporal Discounting Operation. The second component of the temporal discounting model is described by Equation 2.

$$\Psi_{pvt} = S_p S_v / S_t \qquad (2)$$

where Ψ_{pvt} represents the way time and probability adjust the value of an outcome. This component defines the discounting operation for time. It is assumed that when subjects evaluate the stimuli, discounting occurs. This algebraic model does not necessarily assume that subjects "compute" the discounted value. Instead, the algebraic model is used to describe the pattern of responses so that the characteristics of the discounting process can be described easily. Converging evidence was obtained for a ratio discounting model across several types of stimuli.

What are the implications of a ratio discounting operation? In particular how does a ratio discounting operation compare to other alternatives? If one offers an individual a sum of money, for example $100 today how would it compare to an offer of $200 in one year? We know that if both offers were made in the present, the choice would be easy to predict. But when the waiting period is

introduced, an adjustment in the worth must be made. You hesitate in order to determine if the "wait" is worth it. The discounting operation attempts to describe the characteristics of that adjustment in value. Let's consider two alternatives. First, the individual may decide to decrease the value by a fixed amount for every month he or she must wait. This discounting operation may be described by subtraction: $\Psi_{vt} = S_v - S_t$. This pattern is shown in Figure 1a. The values are given on the abscissa and each line represents a different time in the future. The discounted values are represented on the ordinate. Regardless of the value of the outcome, time reduces the value by a fixed quantity. For example, if one views waiting as aversive, it may be viewed as a negative component. Notice that this operation would also imply that when the value of an event is negative, waiting makes the outcome even more undesirable.

Now let's consider an alternative discounting operation. The individual with a choice between $100 now and $200 in one year may decide to reduce the subjective value of $200 by dividing the present value by the number of months until it is obtained. In this case, the future value is some proportion of the current value: $\Psi_{vt} = S_v/S_t$. The pattern of values corresponding to a ratio discounting function is shown in Figure 1b. In this case, the values are given on the abscissa ranging from -$300 to $300 and each line represents a different time in the future. The discounted values are given on the ordinate. One could interpret the effect of time differently in this case. For example, since the future involves uncertainty as to the value of any outcome, it becomes less influential regardless of its nature. In this case positive values become less valuable and negative events become less aversive. Therefore, although both models imply a reduction in value for positive outcomes in the future, quite different implications are obtained for aversive events.

It should be noted that the subtractive and ratio discounting functions for positive outcomes are ordinally consistent. In other words, the same rank order in the stimuli would be predicted by these models. You can convert the ratio combinations to the subtractive combinations by using a log transformation. The exponential transformation will convert the subtractive combinations back to the ratio form. Therefore special designs were used to test these models when positive outcomes were used since the response function was assumed to be nonlinear. In the studies involving both positive and negative outcomes, converging evidence for a ratio discounting function was obtained. The results obtained with investments are described in detail in Stevenson (1986). Similar results were obtained using college support and payback schedules. These results are described in the Technical Report, "The Effects of Temporally Based Work and Payment Conditions on Funding a College Education". Furthermore, this study indicated that the ratio discounting operation best described the individual judgments as well as the grouped data. These results were also replicated in the last study, reported in the Technical Report, "The Effect of Time Frame on the Evaluation of Future Events."

In summary, when subjects are asked to evaluate the worth of single events in the future or to compare two alternatives that vary in the value and time when the outcome will be obtained, a ratio discounting function has been most accurate. It should be noted that in all of these studies the time frame spanned at least 4 years. For situations involving shorter periods of time, a different discounting mechanism might be more appropriate. For example, if asked whether you would prefer to endure a painful medical procedure now or after 15 minutes, it is not clear that all individuals would prefer to avoid the waiting period and

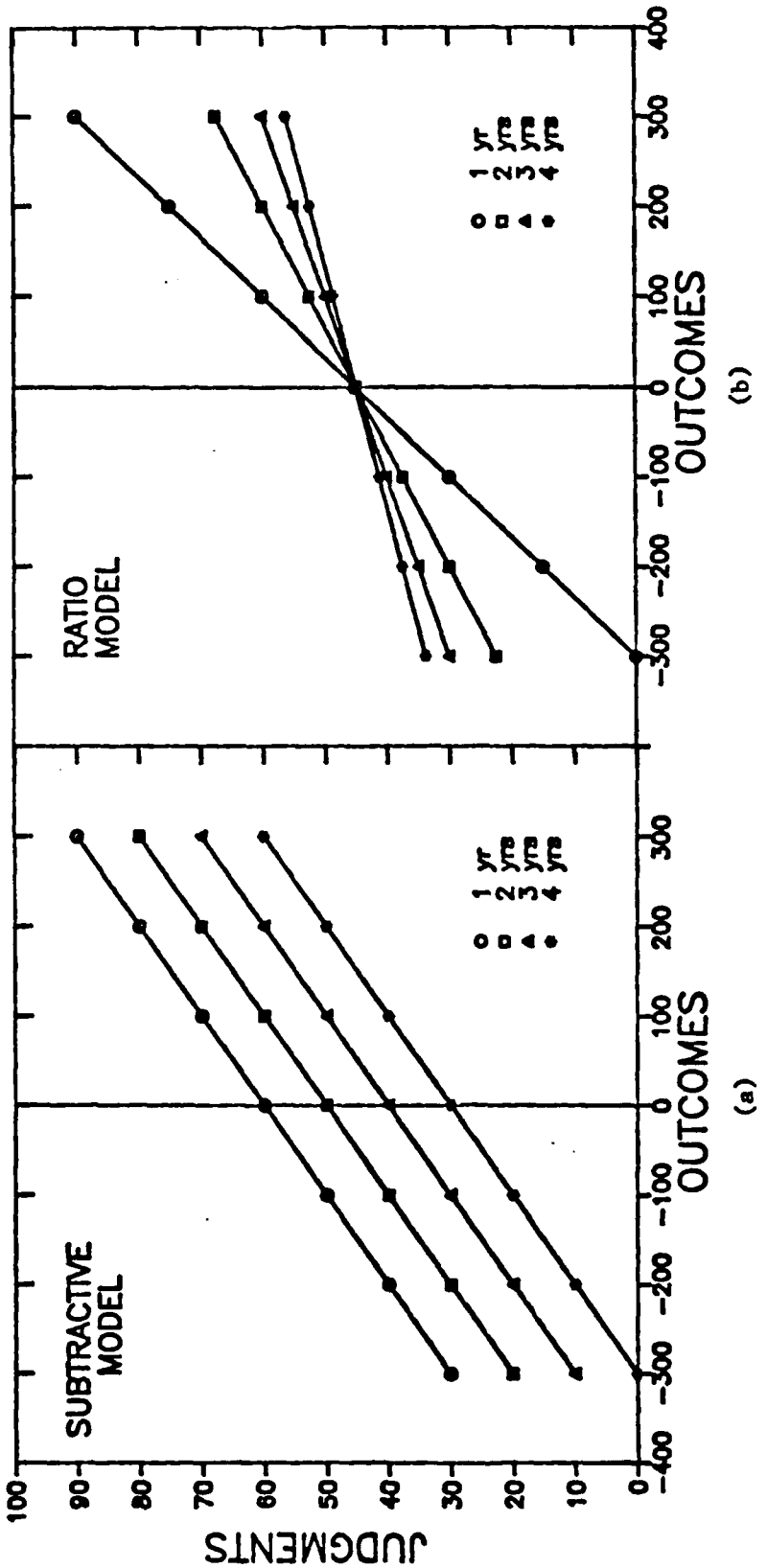
JUDGMENTS
SUBTRACTIVE MODEL
RATIO MODEL
OUTCOMES
(a)
(b)
1 yr
2 yrs
3 yrs
4 yrs
100
90
80
70
60
50
40
30
20
10
0
-400
-300
-200
-100
0
100
200
300
400

FIGURE 1

get it over with quickly. The preference for immediate negative stimuli as opposed to delayed negative stimuli would not be compatible with the current model.

In some situations, it appears that discounting may not occur at all. In one study, college funding programs similar to the programs described for the single outcome studies were described in 1 year segments. For example, the subjects were told that they would be given the opportunity to work part-time during the school year and full time during the summer for minimum wage and a percentage of their college tuition. In order to evaluate these programs the subjects were required to evaluate the "importance" of obtaining support for their first, second, third and fourth year of school, and to combine the value of support across the years that were represented in the stimulus. The important finding with respect to the discounting operation was that in this case there was no indication that the subjects discounted the support as a function of time. Looking at the grouped and individual data, there was no evidence for temporal discounting. Therefore, one could conclude that in some cases, discounting can be eliminated by chaining the events together. However, an alternative explanation could be that when the students evaluated these stimuli, they viewed them as support for a college education. In other words, since college is a four year activity, they were not able to separate and evaluate each year of support. A study was proposed in the current program of research to clarify this effect and the results are currently being analyzed. The details of this study are described in the Technical Report, "Evaluating Multiple Events in the Future".

In another study (Technical Report, "Preference for Job Attributes: Present and Future") evidence against a simple discounting function was obtained. In this case, subjects were asked to evaluate the attractiveness of jobs that varied in the starting salary (present incentive), promotion rate (salary expected in ten years) and the retirement benefits (30-40 year gain). Students majoring in three professions were tested: engineers, teachers and managers. Regardless of the profession, subjects indicated in their ratings that the salary expected in ten years was the most important attribute despite the fact that it would not materialize for ten years. In this case, simple discounting as a function of the time of the outcome was not obtained. These stimuli were similar to the other multiple events tested since each job was described with a series of outcomes.

In summary, it appears that when subjects are evaluating single events in the future, they tend to use a ratio discounting function. When future events are provided as a series that are chained together, discounting as a function of time does not occur. These results indicate quite clearly that the temporal discounting function is not a simple phenomena but must be studied in a variety of situations and contexts in order to understand the implications of time on decision and evaluative processes. This initial work has provided some insight into the characteristics that influence discounting.

Response Functions. The third component of the model describes the strategies that subjects may use with different tasks. The response or judgment function is shown in Equations 3a and 3b:

$$R_{pvt} = J_r (\Psi_{pvt}) + e_{pvt} \qquad (3a)$$

$$P_{AB} = J_p (\Psi_A, \Psi_b) + e_{AB} \qquad (3b)$$

The response function for the single pole rating scale for stimuli describing single outcomes has consistently been shown to be negatively accelerated for the grouped analyses and the single subject analyses. The response function for the preference task has consistently been found to be S-shaped for the groups as well as the individual subjects. The form of the response function for the preference task is similar to the form of the function reported by other investigators (Winsberg and Ramsay, 1981; Rose and Birnbaum, 1975). The studies described in Stevenson, 1986; Technical Report: "The Effect of Temporally Based Work and Payment Conditions on Funding a College Education"; Technical Report: "The Effects of Time Frame on the Evaluation of Future Events" support these results. In order to incorporate these results into the theoretical model, a psychological interpretation of the response functions is needed. The patterns observed may be compatible with more than one interpretation since this interpretation is in fact post hoc. However, using the current hypothesis, studies could be designed to determine if this interpretation is more accurate than are alternative explanations. It appears that the left endpoint on the rating scale for positive stimuli, the right end on the rating scale for negative outcomes, and the center of the scale for the preference scale are reference points for the subjects. Subjects appear to scale the outcomes near the reference point in a manner that corresponds well to the predicted values from the discounting model but as you move away from the reference point the judged values become more similar to each other than would be predicted by the discounting model. Points that occur at some distance from the reference point tend to be small in number and the most extreme values in the stimulus set. Therefore, one interpretation of these patterns is that as the stimuli become more extreme it is more difficult for the subject to scale the differences. For example, once the investments become very desirable they are seen as more "equivalent". Rose and Birnbaum (1975) interpreted the same pattern in a preference rating task as an indication that small differences near the reference point are exaggerated.

In summary, with single outcomes, the form of the response function is very consistent within task and different across the tasks. These results support the idea that if you use different judgment scales for the same stimuli, it is important to understand the characteristics of the response strategies that the subjects use. Without a consideration of the response function, different conclusions could be reached due to the task characteristics.

When subjects are asked to evaluate the desirability of multiple outcomes the response functions have been nearly linear in form. These results are discussed in the Technical Report: "Evaluating Multiple Events in the Future" and Technical Report: "Preference for Job Attributes: Present and Future". It may be the case that when multiple events are combined, fewer multiple events are extreme. Therefore, the negatively accelerated portion of the response function is truncated due to the complexity of the stimuli. Most stimuli in these cases represent both positive and negative outcomes. This is a post hoc explanation and needs further work to establish its validity.

General Summary. Taken together this series of studies has provided a firm empirical data base describing the effect of time on the evaluation of future outcomes. This summary report has pointed out many of the consistencies obtained across studies. The form of the measurement framework has provided a general theoretical structure into which the work can be integrated. I have presented the aspects of the model that have been supported, the discounting function for

single outcomes, the response functions, and the relationship between the scale values obtained in risky and riskless situations.

These studies have also raised new issues and pointed the way for future research. In particular, the use of multiple outcomes and different time frames indicates that the discounting function is not a simple operation but may be expected to vary across situations. Therefore in order to understand the way people evaluate future consequences, a variety of situations must be studied. Further, the temporal discounting theory must provide some guidelines as to the intensity and form of temporal discounting from different points of view and stimulus attributes.

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POTENTIAL APPLICATIONS: The results of this research have direct implications for recruitment incentives since the personnel are offered benefits that will not materialize until they have completed their tour of duty. This research also has direct implications for strategic planning. The measurement issues that have bene discussed relative to the previous work that has been done to measure the attractiveness of incentives.

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